stelco

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PRESENTATION BY
THE STEEL COMPANY OF CANADA, LIMIT
BEFORE
THE POLLUTION CONTROL COMMITTEE
OF
HAMILTON CITY COUNCIL
APRIL 1, 1974

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Mr. Chairman, Members of the Pollution Control Committee, Ladies and Gentlemen:

We welcome the opportunity of meeting with you once more and of responding to the points you have raised concerning our submission of last August to this Committee. For the purpose of clarity, we have divided this presentation into three sections - particulates, SO2 and fluorides - and we will respond to your questions in the same order as the latter were submitted to us in your letter of March 8.

PARTICULATE EMISSIONS

Question 1 - Precipitator Efficiency

The first essential here is to define precisely what is meant by "precipitator efficiency". In essence, the efficiency of an electrostatic precipitator is an exponential function of the gas flow rate through the unit. Since the gas flow rate from a basic oxygen or open hearth furnace varies with time, then the dust collection efficiency will also vary. Because of this factor, statements concerning the efficiency of a precipitator system may seem, at first glance, to be contradictory.

The following "efficiencies" of a particular precipitator system are often quoted:

(a) Design Efficiency - As Specified by the Manufacturer of the Equipment To Meet His Performance Guarantee

This is based on maximum design flows and maximum inlet dust loadings. With respect to the design of current B.O.F. systems, the manufacturer's guarantee is based upon:

1,024,000 Actual Cubic Feet per Minute

At 550 degrees F and 15% moisture by volume

Inlet dust loading at 10 grs/Standard Cubic Feet

Outlet dust loading at 0.03 grs/S.C.F.

Collecting Efficiency 99.7%

Our B.O.F. precipitator system comprises nine units having a total horizontal projected area of 432,000 square feet. Each unit possesses a 48,100 square foot collecting surface which enables it to meet its guarantee efficiency with a gas flow of 128,000 Actual Cubic Feet per Minute.

The design efficiency will be met with eight functioning units and one in reserve.

The design efficiency of an Open Hearth precipitator is 99.1%. Because of the lower inlet dust concentration from open hearth furnaces, this lower efficiency produces equivalent outlet dust concentrations.

(b) Operating Efficiency During Worst 30 Minute Period

The peak conditions referred to under design efficiency for the B.O.F. are based on an assumption of two oxygen vessels blowing simultaneously together with a leakage of tramp air of 126,000 S.C.F.M. (224,000 A.C..F.M.). However, limitations of materials handling systems in the shop along with random effects such as delays, makes simultaneous blowing of vessels a very infrequent occurrence. Should simultaneous blowing occur, the precipitator system is designed to cope with such an eventuality. Since the

maximum blowing time is only twenty minutes, and the heat cycle about 45 minutes, the emission rate for the worst possible 30-minute period is 0.02 grs/ft^3. (This is based on eight units in service and one down for maintenance.

Under these worst possible conditions:

Rate of Dust Emission from the Stack is		1.44 tons/day
For this worst 30 minute period the Rate of Dust Evolution is		398.6 tons/day
During this worst 30 minute period the Dust Collection Rate is:	(398.6 - 1.44) =	396.16 T/D
Collection Efficiency is $\frac{(396.16)}{(398.6)}$	=	99.5%

Similarly, for the O.H. precipitator, the worst 30 min. operating efficiency is 98.8%.

Both the Open Hearth and the B.O.F. are Batch Processes. In other words, a fixed quantity or batch of material is processed in a given time. The process is repeated for a number of similar cycles. It is evident, therefore, that the gas flow, the dust emitted, the waste gas temperature, etc. will all vary from time to time during a day.

There will be periods of peak activity and periods in between cycles when the process is stopped.

(c) Daily Average Collecting Efficiency

At the B.O.F., the peak flow of 1,024,000 C.F.M. and peak inlet loading of 10 grs/ft^3 assumes two oxygen vessels blowing simultaneously along with an uncontrolled air leakage into the system of 126,000 S.C.F.M. (or 224,000 A.C.F.M.). In a time.period of 45 minutes (heat cycle time) maximum gas flow and maximum dust evolution can only occur for about 15 minutes. Furthermore, limitations in the material handling systems of the shop make simultaneous blowing of two vessels an infrequent occurrence.

Therefore, on a day round basis the most probable daily average collecting efficiency is as follows:

1 Vessel blowing -

Gas Flow 867,000 A.C.F.M.

For 9 units operational - flow per unit - 96,333 A.C.F.M.

$$N = 100 (1 - e^{-7.7186}) = 99.96\%$$

The weighted average inlet loading 5.0 grs/ft^3

Dust concentration in stack .0022 grs/S.C.F.

For 8 units operational (1 out of service)

Flow per unit 108,375 A.C.F.M.

$$N = 100 (1 - e^{-6.8609}) = 99.9\%$$

Therefore the daily average collecting efficiency is in the range of 99.9% at the B.O.F. and 99.62%at the Open Hearth.

Either design efficiency or daily average collecting efficiency has constituted the basis for our past statements regarding efficiency. Both methods of calculation are valid but the results of each must be read in context.

DUST EMISSIONS

Having discussed efficiency, we will now turn to Table 1, on page 6 of our August brief to explain how it was produced.

Your question to us related to the extent of our emissions. In order to avoid any possibility of understating the problem we provided maximum figures which erred on the side of caution.

The Third Column entitled "Dust Collected" is based on weights of dust collected at various environmental facilities throughout the Company. Being an actual figure, it takes into account the high and low periods of flow and concentration in the system and thus is a daily average.

The Last Column entitled "Dust Emitted" was the figure you asked for and we wished to give you quantities which were beyond question. The figures shown in this column for Casthouse emissions and Open Hearth Roof Monitors are based on actual tests. The emissions shown for the Open Hearth and B.O.F. precipitators have been estimated based on worst 30 min. flow rate. By this, we mean that the thirty minute emission rate has been stated on a twenty-four hour basis even though we know that this maximum occurred for only short periods during the day. This was done in order to produce

a maximum figure which could not be disputed. Since we do not operate under maximum conditions all day, the actual daily average figure will be less, and we have calculated this average figure from the Open Hearth precipitators to be 1.29 tons/day as compared to the peak figure of 7.33 tons/day shown on Table 1. Such being the case, we believe that the emissions are no greater than the ones shown in that last column, and are in fact considerably less.

The second column entitled "Dust Produced" was arrived at by adding the dust collected and the dust emitted. If the dust emitted figure is conservative, as explained previously, the dust produced figure is also conservative. For example, if the calculated <u>average</u> emission figure of 1.29 T/D is used for the Open Hearth Furnaces, the dust produced becomes 218.96 T/D. Because we deliberately erred on the side of caution by overstating our emissions, your calculations regarding efficiency are artificially low and therefore do not agree with the methods of establishing precipitator efficiency as explained earlier.

Question 2 - Page 2 - Sinter Plant

As stated in our August, 1973 submission, each sintering installation is faced with different problems because of the varying mix of feed materials passed into this scavenger operation. Our studies have now pointed us toward a combination scrubber and wet precipitator approach, and pilot trials will have to be undertaken to prove out the operation of the air cleaning system as well as treatment systems for the water waste created. A pilot plant became available in January but arrived on site in a damaged condition.

Allowing time for repairs and installation of equipment, in-line tests on gas streams from varying sinter strand burdens, specifications, ordering, delivery, and construction of equipment, we had established the end of 1975 as a target date for the start up of full scale operation. However, due to the problems associated with receiving this pilot plant and the uncertainties which presently exist in the current market regarding supply of all the necessary materials, completion could be delayed until the middle of 1976. Nevertheless, we will make every attempt to meet the earlier date if at all possible.

The emission reduction as stated in Tables 1 and 2 of the August brief is expected to be 3.4 tons per day (3.6 tons per day reduced to 0.2 tons per day).

Question 3 - Open Hearth - #16 Furnace

The shutdown of #16 Furnace on November 1, 1973 completed the phase out schedule of the entire #2 Open Hearth steelmaking operation. The waste gas duct system from #16 furnace has been totally isolated with a blank from the gas cleaning complex at #3 Open Hearth. The electrostatic precipitator, which originally served #16 furnace, now augments the precipitator system of #3 Open Hearth.

Question 4 - Baghouses

As explained in our August brief, we have installed a Multi-Cyclone Collector on #1 Hot Metal Reladling Station. Although pilot testing with this type of equipment had indicated that it would be adequate, the full scale unit does not clean the effluent to our satisfaction. Therefore, #2 Hot Metal Reladling Station has been equipped with a baghouse installation and this was completed prior to our last meeting.

This unit cleans the air satisfactorily, but there were minor problems with ancillary equipment. These have been ironed out and the equipment for #1 Station has been redesigned and is on order. We expect to have this replacement equipment operational by July, 1974. We would like to stress, however, that this source already has a collector in use and the new installation represents an improvement to existing facilities

Question 5 - Open Hearth Roof Monitors

The Ontario Research Foundation study has been completed and the subsequent report confirms the preliminary information given on page 18 of our August submission. Projections from their test work over a section of the shop indicate emissions of 1.63 tons/day from the entire shop. It has been estimated that to collect these emissions would require equipment to move and clean 4.4 million cubic feet of air per minute. The capital cost would be in the range of 25 million dollars, representing an outlay of more than 15 million dollars for each ton of dust per day collected. This compares with costs of $22,400 per ton of dust per day collected in 1970 and reflects the large volumes of air that must be handled to collect minor concentrations of dust.

The average grain loading as measured by O.R.F. is 0.00383 grs/ft^3. The peak is 0.011, which is less than the concentration from a stack equipped with a high efficiency collector. However, because of the large extent of the monitor, a visible discharge is occasionally noticed. We feel that existing methods of control are neither technically nor economically feasible and we are therefore continuing to investigate new technology in this particular field.

Question 6 - Miscellaneous Items

On page 23 of our August brief, we pointed out that the percentage of iron oxide in the total dust fall indicated that Stelco's process emissions may represent only a small proportion of the total dust fall.

In order to throw more light on that conclusion, we have plotted Ministry of the Environment dust fall data at certain stations for the years 1969 through 1973 on exhibits D1 to D6 attached. Graphs D1 and D2 indicate that dust fall at the Burlington and Ottawa sampling station was higher during the three months of 1969 when Stelco was not producing, than in subsequent years when we were operating at full capacity.

Dust fall readings, at the North Park, Beach Strip Station, slide D3, during the 1969 strike were lower than some subsequent years during that period, but the 1969 readings were also lower during that year when we were operating.

Graph D6 shows an average dust fall for ten stations for which we had comprehensive data. Again no consistent pattern of lower emissions during the three month strike period is visible.

Graph D7 is a plot of average dust fall for six stations for the months of August, September and October, being the strike months, over a period of years. The six stations were chosen because they were the only stations over that extended number of years for which we had reasonably complete data. You will note that during the three-month strike period in 1969 the dust fall was not significantly lower than the same three month period in subsequent or preceding years.

It is not our intention to infer that Stelco is not a contributor to dust fall. To the contrary, in our August brief we admitted to considerable emissions. Nevertheless, we suggest that perusal of the aforementioned background data indicates that even when our processes are shut down a major portion of the dust fall at the various measuring stations remains.

Whatever the cause of this anomaly may turn out to be we at Stelco are proceeding with the development of facilities to clean up known sources of particulate emissions such as coke ovens and the sinter plant for which appropriate technology is now emerging.

Question 7

In our August brief Mr. Harris stated that we expect to achieve a better than 90% cut back in particulate matter emissions from Hilton Works by 1975. In fact, the brief showed that our cut back had already reached the 95% level in 1973 and we would reach the 97.8% level by the time our programme was completed. The areas where these reductions would be made up to the end of 1973 are shown in table 1 and further reductions beyond that data are indicated on table 2. Additional explanation of these changes was given in the written portion of our August submission.

SO^2 EMISSIONS

In our presentation to you last August, we stated that we would complete a study of gas desulphurization processes on this continent and abroad by the end of 1973. We hoped at that time to be in a position to select a process and discuss a project completion date. A task force of three senior technical specialists completed this investigation as planned, and has produced detailed analyses of seven processes now used or planned in Europe, The United Kingdom, and North America. Two Japanese processes were also included in this analysis.

We have learned that all of these processes can produce sulphur-free gas, but only at the expense of producing other sulphur compounds which themselves become a difficult disposal problem. Of even greater concern, perhaps, is the fact that some of the "improved" processes of today produce highly toxic wastes for which there is no acceptable means of final disposal. In order to achieve high efficiencies of sulphur removal, several commercial processes employ heavy metal catalysts (such as arsenic) which create toxic solid wastes. It is our opinion that processes of this type would be completely unacceptable to our employees and to the community.

In view of these rather disappointing findings, we now propose the following action:

1. To maintain active liaison with equipment builders at home and abroad.

   We have appointed a Senior Engineer to monitor these activities and have retained consultants in Japan and the United Kingdom to maintain an active watching brief.

2. To develop an active research program to investigate and develop effective technology for pollution control specific to our industry.

   We plan to strengthen our Research Department in this area of expertise with the intention of adapting, modifying, or developing suitable processes where these are not available commercially.

I might mention here, Mr. Chairman, that the foregoing represents a summary of the action we have undertaken in this particular area. If it is the wish of this Committee, we are prepared at this moment to go into further detail on the investigations we have undertaken and discuss some possible future technological developments in this field. In any event, a complete outline of our approach to this problem is attached as an appendix to this presentation.

FLUORIDE EMISSIONS

Question 1

On page 37 of our August brief we recounted that when fluorides first became a concern, we initiated tests of our stack emissions and of ambient conditions a half a mile from our steelmaking furnaces. These ambient impingement tests completed in July 1971, revealed that the maximum half hour limit of 5 parts per billion was exceeded for only 3.7% of the time under the operating conditions which existed at that date.

Having defined the problem, our next action was to shut down progressively our #2 Open Hearth furnaces which were not equipped with precipitators starting January 1, 1972 and ending June 14, 1972. This significantly reduced our emissions both of fluorides and particulate matter. Thus the test data on which your statement in question one was based is no longer valid. Further details of our program will be discussed in our answers to your other questions.

Question 2

Controlled impact assessment studies have not been initiated by Stelco. The entire subject of flux alternatives has not, as yet, been completely resolved. However, the testing program has made significant progress to the point where we can now state unequivocally that fluorspar flux will not be used in the Open Hearth steelmaking process. In accordance with the testing program and operating experience, we intend to substitute Manganese Ore for Colemanite by the middle of 1974.

When we reported our findings in August, 1973, the data represented the latest available operational information on a very new technology and was not to be construed as all embracing. The problem is particularly vexing since both steelmaking and environmental requirements must be satisfied. In this vein, we do not intend to trade one problem for another. Because we are cognizant of the nature of the Boron family, we have taken a cautious approach to this particular development. Stack measurements have shown that in comparison to fluorspar application, Colemanite usage resulted in substantially lower fluoride emissions. This is to be expected, since Colemanite does not contain fluorides.

Certainly with an alternative chemical, a change in the stack composition must be expected. But as long as emissions are within the range of known regulations, we believe that our approach should be considered a satisfactory one. In terms of Colemanite, Boron emissions are possible, but the precise molecular compounds which are involved are not known. Most likely, the element Boron, which the chemist reports, is in the oxide or borate form. Because only minimal concentrations of Boron-containing materials were found, additional stack investigations and particulate characterization have been terminated.

The maximum calculated ground level concentration for elemental Boron was found to be 0.7 ppb.

As a result of our research, fluoride levels have shown a decrease. The Boron levels were generally higher throughout the Hamilton area in 1973. According to the Air Management Branch, however, these levels are not considered to be in the injurious range with respect to foliage. In addition, high-volume air sampling in 1973 by the Air Management Branch in the Hamilton area has shown that Boron was present only in trace amounts in the ambient air. By extrapolation these emissions are even less likely to be deleterious to humans.

Question 3

The testing program relating to our search for an alternative flux to fluorspar has been thoroughly discussed with the Air Management Branch. Stack test results were made available as part of the information exchange. These preliminary tests indicate that for potentially toxic substances, the regulations have been met.

Formal notification for the full scale Open Hearth tests were given to the Ministry which included the composition of the intended fluxing material. The same information was reviewed with your committee in August, 1973.

The Ministry agreed with the test work in principal. Approval can only be obtained after completing the test work and then reviewing the relevant stack and ambient test data with the Air Management Branch. Once all evaluations have been completed and the suitability of a fluxing agent has been established, a formal application will be made.

Question 4

With respect to this particular question, it might be appropriate to briefly review the progress which Stelco has made to date with respect to the control of fluoride emissions.

The problem of fluoride emissions from steelmaking operations was first brought to our attention as a result of our membership in the American Iron and Steel Institute, our direct participation in the Institute's Environmental Control Committee and contacts with other steel companies throughout the world.

Stack evaluations and emission characterization was started in April, 1970. The preliminary data was discussed with the Air Management Branch three months later. After completing a literature search and plant visitations in Europe, a positive testing program was initiated in August, 1971 to screen various potential fluxing agents. On the basis of the research results, production scale test heats were started in January, 1972 at #3 Open Hearth. Some aspects of this test work were discussed with your committee in August, 1973, including the chemical compositions of the fluxing agents.

Our findings indicated that Manganese Ore and Colemanite fluxing agents can be used to replace fluorspar. The application of these alternatives eliminated the fluoride emissions from this source. Finally, fluorspar usage was terminated in the Open Hearth in March, 1973.

Based on the experience gained since then, our intention now is to carry out an extensive trial with Manganese Ore once Colemanite stocks have been depleted. This change is expected to take place in July, 1974. Within this framework of dates, background information and test reports, your committee has participated in the progress and evolution of a novel steelmaking practice.

In summary, therefore, the fluoride problem at No. 3 Open Hearth has been under control since March, 1973. The shutdown of uncontrolled furnaces at No. 2 Open Hearth was completed in June, 1972, thereby eliminating the fluoride emissions from that source. Our Baxic Oxygen facility has been in compliance with established regulations ever since its inception in December, 1971. As a result of this voluntary program, the fluoride problem has been resolved and we respectfully submit that a Ministerial Order is not required for this particular field.

With respect to the final point raised in your letter of March 8, the reports which you requested at our last meeting were sent to Mr. E. A. Simpson on August 23 of last year. If you would like any additional copies, we will be happy to furnish them.

We trust that this presentation has answered your questions satisfactorily. If you feel that we have gone into an inordinate amount of detail, then we hope that you will accept that this stems not from any desire to confuse, but rather from a wish to avoid oversimplifying an extremely complex problem and to provide you with as much information as possible. I would like to reiterate our desire to establish with your Committee the type of relationship that will permit us to work together in seeking to upgrade the environment of the community of which we all form part.

And now, ladies and gentlemen, if you have any further questions, we will be happy to try and answer them.

COMPARISON OF AVERAGE MONTHLY DUSTFALL
TO STEEL PRODUCTION IN 1969
STATION No. 29010
BURLINGTON - OTTAWA

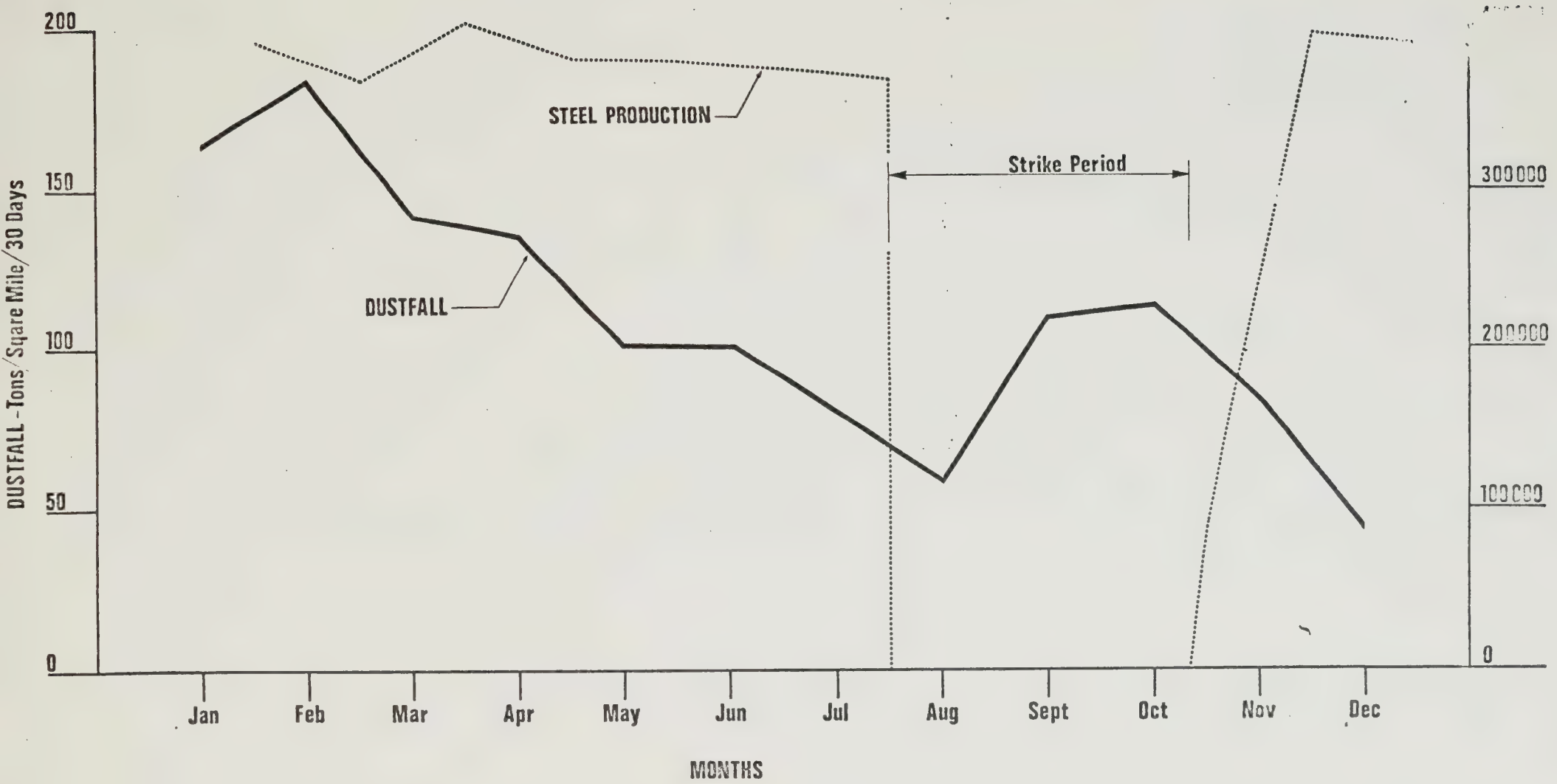


Exhibit D-1

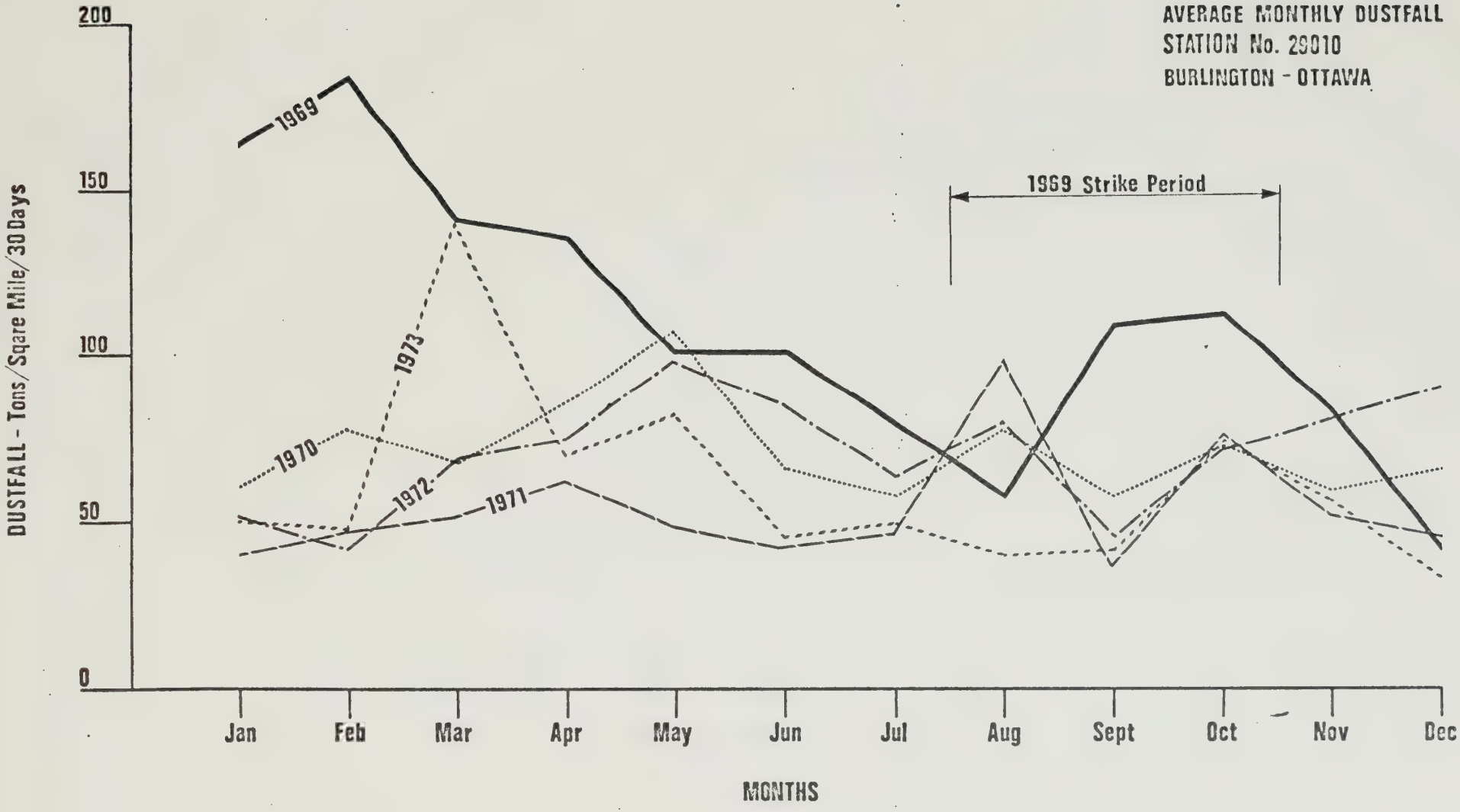

AVERAGE MONTHLY DUSTFALL
STATION No. 29010
BURLINGTON - OTTAWA
1969 Strike Period
1969
1973
1970
1972
1971
DUSTFALL - Tons/Sqare Mile/30 Days
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
MONTHS

Exhibit D-2

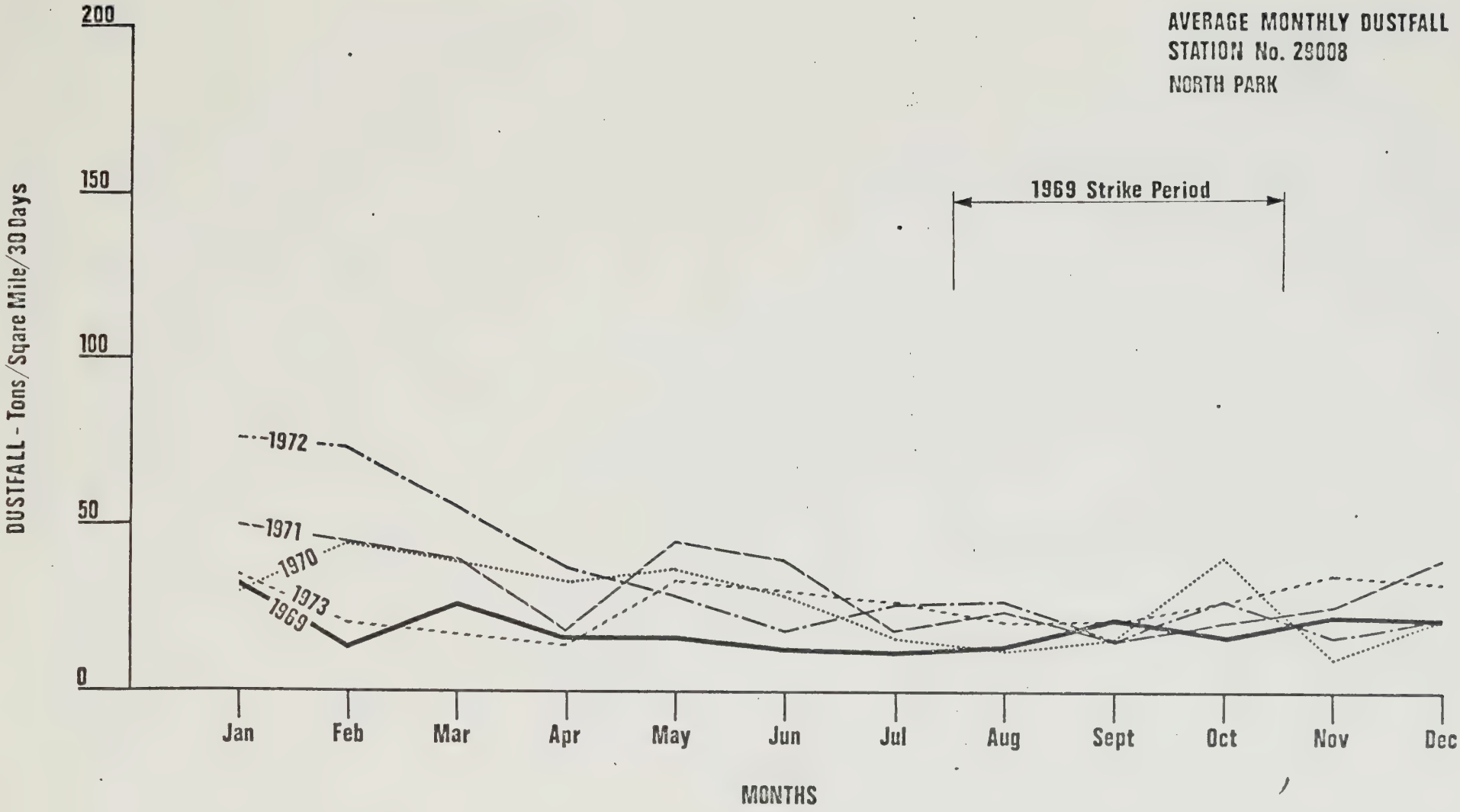

AVERAGE MONTHLY DUSTFALL
STATION No. 29008
NORTH PARK
1969 Strike Period
DUSTFALL - Tons/Sqare Mile/30 Days
200
150
100
50
0
1972
1971
1970
1973
1969
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
MONTHS

Exhibit D-3

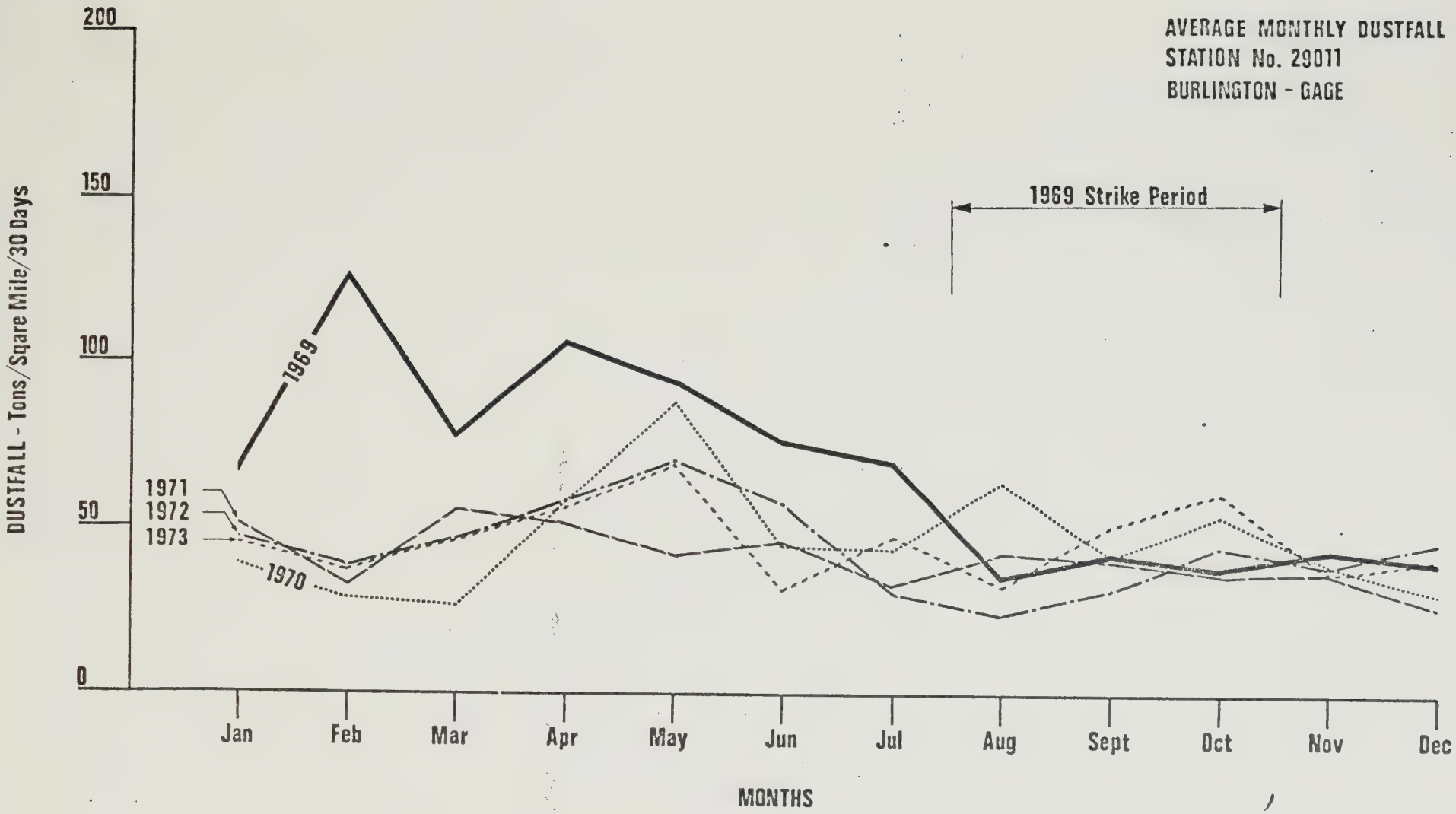
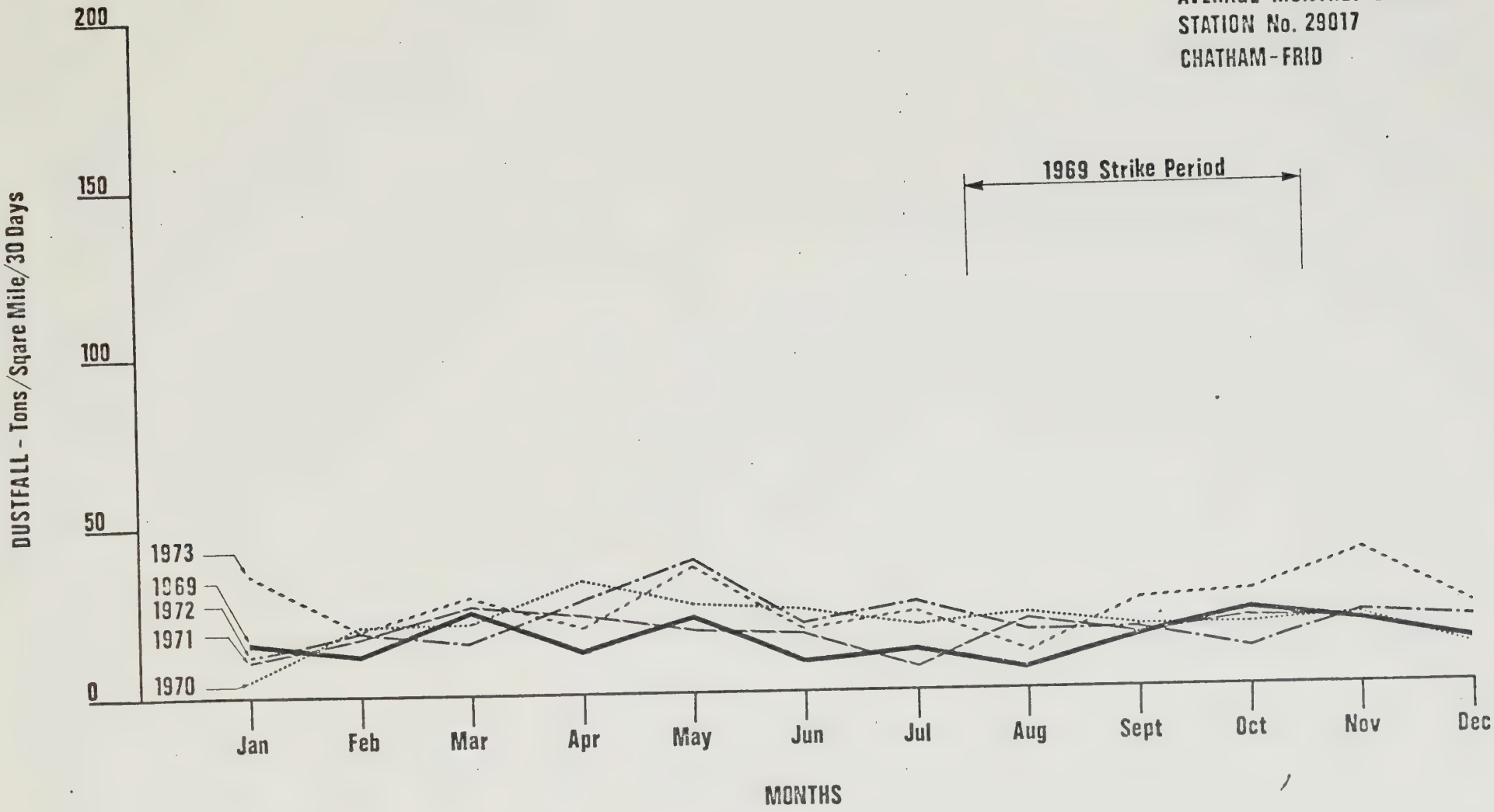

AVERAGE MONTHLY DUSTFALL
STATION No. 29011
BURLINGTON - GAGE
1969 Strike Period
DUSTFALL - Tons/Sqare Mile/30 Days
200
150
100
50
0
1969
1971
1972
1973
1970
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
MONTHS

Exhibit D-4

AVERAGE MONTHLY DUSTFALL
STATION No. 29017
CHATHAM-FRID



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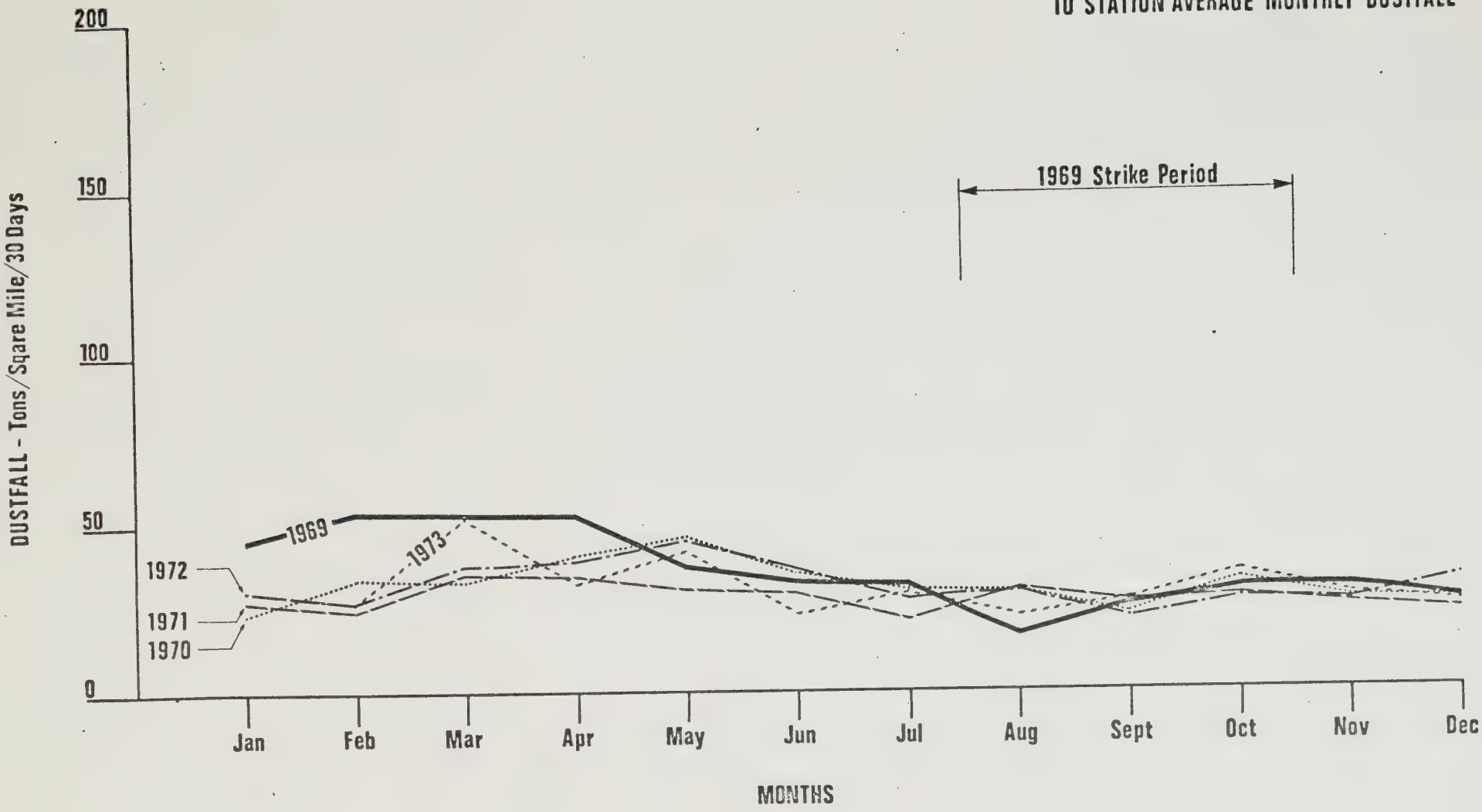
10 STATION AVERAGE MONTHLY DUSTFALL
1969 Strike Period
DUSTFALL - Tons/Sqare Mile/30 Days
200
150
100
50
0
1969
1973
1972
1971
1970
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
MONTHS

Exhibit D-6

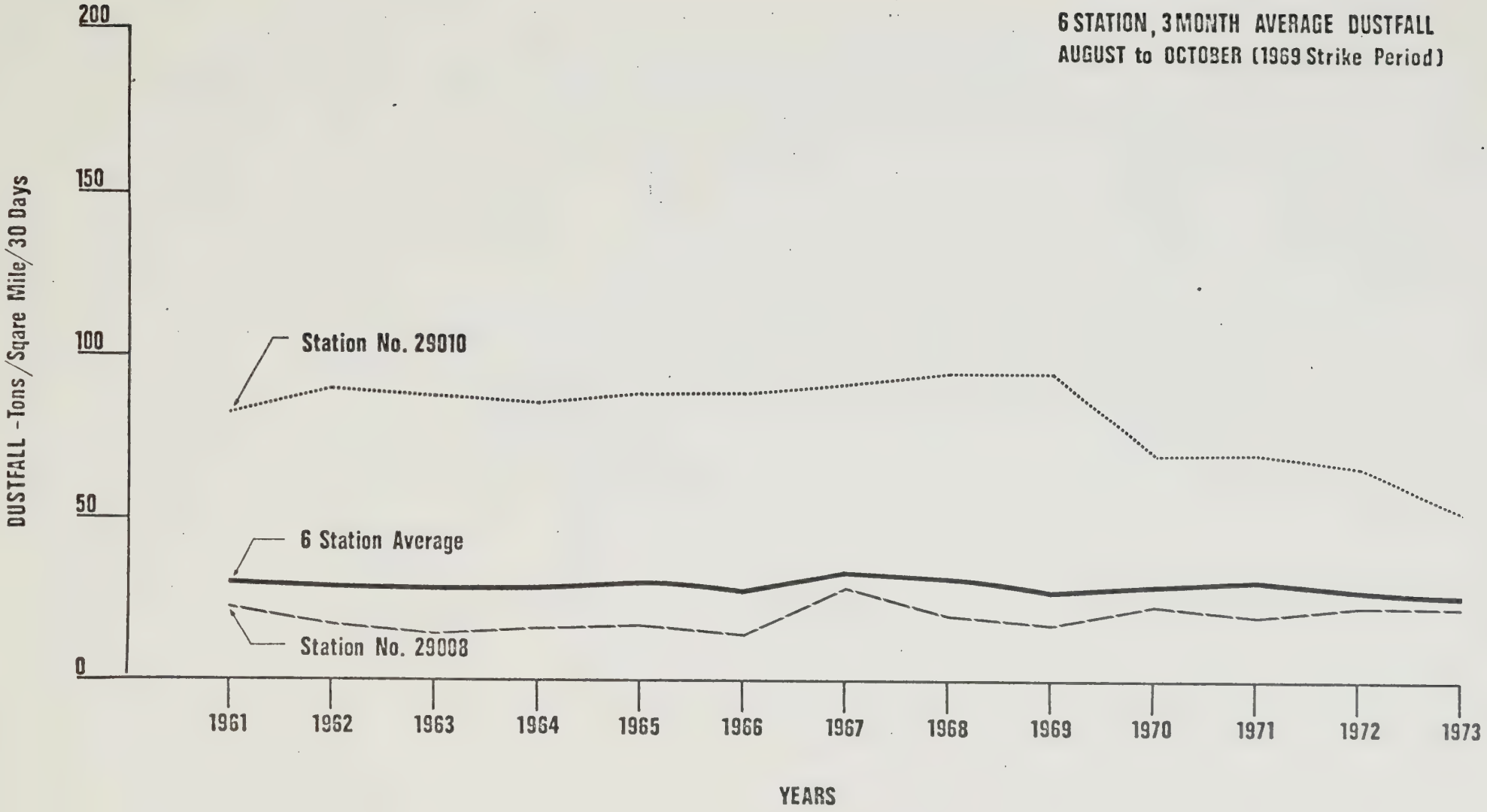
6 STATION, 3 MONTH AVERAGE DUSTFALL
AUGUST to OCTOBER (1969 Strike Period)
DUSTFALL - Tons/Sqare Mile/30 Days
200
150
100
50
0
Station No. 29010
6 Station Average
Station No. 29008
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
YEARS

Exhibit D-7

DATA SOURCE
FOR

EXHIBITS D-6, S-1

TEN DATA STATIONS USED AS
IDENTIFIED BY AIR MANAGEMENT
BRANCH OF ENVIRONMENT ONTARIO

Station Number	Location
29001	Hughson & Main
29003	Burris & Main
29006	Queenston
29008	North Park
29009	Kenilworth
29010	Burlington & Ottawa
29011	Burlington & Leeds
29012	Burlington & Wellington
29017	Chatham & Frid
29019	Mohawk & James

These stations were selected as having reasonably complete data for the period 1969 to 1973.

HHE:CP:DLaC
March 19, 1974

DATA SOURCE
FOR

EXHIBIT D-7

SIX DATA STATIONS USED AS
IDENTIFIED BY AIR MANAGEMENT
BRANCH OF ENVIRONMENT ONTARIO

Station Number	Location
29001	Hughson & Main
29003	Burris & Main
29006	Queenston
29008	North Park
29010	Burlington & Ottawa
29017	Chatham & Frid

These stations were selected as having reasonably complete data for the period 1961 to 1973.

HHE:CP:DLaC
March 19, 1974

APPENDIX 1 SO2

Mr. Chairman and Members of the Pollution Control Committee:

1. Summary

In our presentation to you last August, we stated that we would complete a study of gas desulphurization processes on this continent and abroad by the end of 1973. We hoped at that time to be in a position to select a process and discuss a project completion date. A task force of three senior technical specialists have completed this investigation as planned, and have produced detailed analyses of seven processes now used or planned in Europe, The United Kingdom, and North America. Two Japanese processes were also included in this analysis.

We have learned that all of these processes can produce sulphur-free gas, but only at the expense of producing other sulphur compounds which themselves become a difficult disposal problem. Of even greater concern, perhaps, is the fact that some of the "improved" processes of today produce highly toxic wastes for which there is no acceptable means of final disposal. In order to achieve high efficiencies of sulphur removal, several commercial processes employ heavy metal catalysts (such as arsenic) which create toxic solid wastes. It is our opinion that processes of this type would be completely unacceptable to our employees and to our community.

In view of these rather disappointing findings, we now propose the following action:

1) To maintain active liaison with equipment builders at home and abroad.

   We have appointed a Senior Engineer to monitor these activities and have retained consultants in Japan and the UK to maintain an active watching brief.

2) To develop an active research program to investigate and develop effective technology for pollution control specific to our industry.

   We plan to strengthen our Research Department in this area of expertise with the intention of adapting, modifying, or developing suitable processes where these are not available commercially.

2. Investigation of H_2S Removal Processes

Desulphurization of coke oven gas has been practised for many decades. Initially, processes were well-developed in Europe, primarily as a means of purifying the coke oven gas for use as town gas which was used to illuminate the streets of large cities such as London, England, as long ago as the early part of the nineteenth century. The early processes were unsuited to the treatment of very large volumes of gas. Developments in the last few decades have largely followed from the need to desulphurize larger volumes of natural gas.

The available processes for the removal of hydrogen sulphide from coke oven gas are of two types: dry processes and wet processes.

In the dry processes, the gas is passed through beds of solid iron oxide or other absorbent. When the solid becomes saturated with sulphur, the bed is regenerated by passing air through it, but ultimately, the bed becomes exhausted and the solids have to be discarded. This process is adequate for treating relatively small volumes of coke oven gas, but a very large plant covering several acres would be needed to process the gas supply for Hilton Works. In addition, the changing of the beds is an unpleasant, manual job and suitable absorbents are in short supply. There is also a solids disposal problem. These factors have led to attempts to develop fluidized bed techniques, but none of these have proceeded beyond the large pilot stage, and in any case, disposal problems still remain.

The disadvantages of the solid absorbent methods led to the development of a second class of process, using liquid absorbents.

In the liquid purification processes, the coke oven gas is contacted with an alkali solution in a scrubbing tower. The solution is continually circulated from the tower through a regenerator tank, where the sulphur compounds are removed from the solution. The revived solution is then pumped once again to the absorber tower.

Table 2.I: Coke-Oven-Gas Desulphurization Methods

Regeneration Product	
Sulphur	Hydrogen Sulphide
Stretford	Vacuum Carbonate
Giammarco-Vetrocoke	Sulfiban
Fumaks	Carl Still
Amox	Sulfammon
Otto-Sidmar	
Takahax	

Table 2.II: Some Chemical Additives Used in Various Coke Oven Gas Desulphurization Processes

Process	Additives
Stretford	anthraquinone disulphonic acid sodium metavanadate
Giammarco-Vetrocoke	arsenic oxide
Fumaks	picric acid
Amox	arsenic oxide hydroquinone
Otto-Sidmar	iron sulphate

The removal of sulphur compounds from the absorbent produces either sulphur or hydrogen sulphide, according to the nature of the particular process. Table 2.I lists the processes studied by the Stelco task force in terms of the regeneration product (sulphur or hydrogen sulphide). Visits were made to plants or pilot plants operating eight of these processes in Europe or North America.

The regeneration products present a disposal problem, but this was not a major concern when the processes were originally developed. It has been common practice, for example, to either release regenerated hydrogen sulphide gas to atmosphere or to burn it to sulphur dioxide which was then discharged. Neither of these practices would be thought acceptable today. At first sight, the processes producing solid sulphur (left-hand column in Table 2.I) would present less of a disposal problem than those producing hydrogen sulphide. However, the situation is further complicated by several factors:

1) Coke oven gas contains many other impurities besides hydrogen sulphide. These impurities produce compounds in the absorbing solution which reduce its efficiency. The normal procedure is to remove a proportion of the solution (say 4000 gallons) each day and dispose to sewer, making up with water and fresh chemicals. These discarded solutions typically contain large amount of thiocyanates, thiosulphates, sulphides and other noxious compounds, but it is believed by many that dilution in sewage solves the disposal problem. This is present practice, for example, at plants in the United Kingdom. In addition, it is usual to completely drain the plant once every six months to a year. This liquor, in volumes of perhaps 150 000 gallons, is also normally disposed to sewer.

2) In order to act as a regenerator of sulphur, the absorbing solution must contain other chemical additives. The different processes use different chemicals, of varying toxicities (Table 2.II). These compounds are present in the effluent disposed to sewer. In addition, they also appear as contaminants in the sulphur sludge, along with thiocyanates and thiosulphates, which complicates disposal.

During our visits to installations where coke oven gas desulphurizing units were in operation (Table 4.I), we became increasingly concerned that the available processes for removing sulphur from coke oven gas were only operating at the expense of creating severe liquid and solid disposal problems. Information from our technical contacts in Japan indicates that the situation is no better with the Japanese processes, "Takahax" and Fumaks". Discussions with equipment suppliers have confirmed that this is the present situation, although some suppliers are now claiming that it will soon be possible to completely solve disposal problems. In other words, these suppliers are claiming that new technology can form the basis of a plant design which would produce no noxious effluents. However, no full-scale operating plants demonstrating the feasibility of such technology have yet been built. We understand that the first, a modification of the Stretford process, is due to come into operation at the British Steel Corporation, Redcar, England some time in 1975.

3) Alternative Methods for the Control of Sulphur in Gaseous Emissions

Sulphur dioxide is a nearly universal air pollutant because it is present in the combustion products of all fossil fuels (primarily coal and petroleum). Sulphur oxide emission control must, therefore, be based on one of two possible methods:

1) complete removal of sulphur from all fossil fuels before combustion; or

2) complete removal of sulphur dioxide from the combustion gases at every site where fossil fuels are consumed.

Neither method is altogether feasible, for a combination of technical and economic reasons.

The first, removal of sulphur from all fuels, is practical in the case of fuel oils, although at substantial increases in cost of energy supplied in this form. Removal from our other prime energy source, coal, however, is technically difficult and inefficient.

Processes have reached only the advanced experimental stage and promise to be prohibitively expensive in terms of material and energy requirements should they ever reach full-scale commercial operation. In any case, about 80 percent of the sulphur in our coal supply ultimately ends up in blast furnace slag and only about 20 percent enters into the coke oven gas from which it can potentially be emitted into the atmosphere as sulphur dioxide after combustion. Desulphurization of coal is thus an inefficient way of solving the problem, as well as being technically and economically unattractive.

The second alternative, complete removal of sulphur dioxide from all combusted gases, has not yet been perfected technically. This is because it is difficult to remove impurities at low concentrations efficiently from large volumes of hot gases. The technology is probably most highly advanced in Japan, where experimental units have used powdered lime sprays to absorb sulphur dioxide from flue gases, particularly in electrical generation stations. If such units are perfected, they will require large quantities of energy and absorbent, and will create a solids disposal problem. Furthermore, the provision of an absorbing unit at every site at which fuel is burned would be cumbersome, complex and require large capital outlays.

The partial reduction of sulfur dioxide emissions through the removal of sulfur from our main intermediate fuel, coke oven gas, may be a viable proposition, provided it substantially solves the overall sulphur dioxide pollution problem in Hamilton and district. The table below, reproduced from our Report to the Pollution Control Committee dated August 14, 1973, indicates that a potential reducion in Stelco sulphur dioxide emissions of greater than half appears possible if all coke oven gas at Hilton Works is desulphurized.

Table 3.I: Estimated Total Sulphur Dioxide Emissions, Hilton Works

Source	Mass of Sulphur Dioxide Emitted tons per day	Percentage of Total Daily Emission
Low sulphur oil (0.93% S)	10.3	20.2
High sulphur oil (2.0% S)	6.5	12.8
Coke oven gas	33.0	65.0
Sinter plant	1.0	2.0
Total daily emission of sulphur dioxide	50.8	100

Table 4.I: Processes - Chemicals and By-Products

Process	Absorbent	Products			Chemical Additives	Sites Visited
		Solids	Gases	Liquids		
Stretford	sodium carbonate solution	sulphur sludge	-	daily effluent, and occasional disposal of complete solution	anthraquinone disulfonic acid sodium metavanadate	Dofasco, Hamilton, Ont British Steel Corp, Sheffield, England W.C.Holmes, Huddersfield, England
Gia[illegible]co-Vetrocoke	sodium carbonate solution	sulphur sludge	-		sodium arsenate	Norsk Kokswerk AS, Mo-I-Rana, Norway Dr. C. Otto, Bochum, Germany
Fumaks	sodium carbonate solution	(sulphur sludge)	-		picric acid	-
(Fumaks-Rhodacs)*	(ammonia solution)	(sulphur sludge)	-		(picric acid)	-
Amox	ammonia solution	sulphur sludge	-		arsenic oxide, hydroquinone	Dr. C. Otto, Bochum, Germany
Otto-Sidmar	ammonia solution	sulphur sludge	-		iron sulphate	Dr. C. Otto, Bochum, Germany
Takahax	sodium carbonate solution	(sulphur sludge)	-		1.4 - naphthaquinone 2 - sodium sulphonate	-
Vacuum Carbonate*	sodium carbonate solution	-	hydrogen sulphide (hydrogen cyanide)		-	Dr. C. Otto, Bochum, Germany
Sulfiban	ethanolamine solution	-			-	Bethelehem Steel Corp., Lackawanna, NY
Carl Still	ammonia solution	-			-	Carl Still, Recklinghausen, Germany
Sulfammon	ammonia solution	-			-	Dr. C. Otto, Bochum, Germany

* not investigated in this study

4. Future Technological Development

As mentioned in Section 2, some equipment suppliers are now claiming to have perfected technology capable of being the basis of a plant design which would produce no noxious effluents. We have seen pilot plants and been given descriptions of several possibilities, but none of these have reached the stage of a full-scale commercial plant. We believe, therefore, that the concepts are not fully proven.

There are two technical bases for such plants. The first of these applies to those plants producing sulphur sludge as the main product. In this case, it is claimed that methods have been developed which will treat the daily effluent, giving only products which are harmless or which can be returned to the Stretford plant itself. Even assuming such complete success at eliminating daily effluent disposal, it is difficult to see how the necessity of periodically draining and disposing of the plant liquor can be completely eliminated, although the time period between such shutdowns may be extended to several years.

The second technology applies to those plants producing hydrogen sulphide gas as the main product. Technology is available to convert gas streams of *pure* hydrogen sulphide to solid sulphur (by the Claus process) or to sulphuric acid (via oxidation of sulphur dioxide and sulphur trioxide). Unfortunately, the hydrogen sulphide gas effluents from coke oven gas desulphurizing units are impure. In particular, they contain traces of hydrogen cyanide gas which, besides being highly poisonous to life, is also poisonous to the activators (catalysts) used to convert the hydrogen sulphide to the required products. This poisoning action introduces further complications to the processes and the problem has not been solved. Table 4.I summarizes the major by-products and chemical additives associated with the desulphurization processes we have examined.

5. A Case for Deferred Construction

You have seen that the best available technologies for removing sulphur compounds from gas steams are not completely satisfactory from the environmental viewpoint. This type of equipment is expensive to own and to operate and the fuel consumption of such a process is itself an additional contribution to the total waste gas production.

With these very evident shortcomings then, we might well question why such equipment is in service at all. The reason is that these processes do remove sulphur compounds from gas, and where this must be done for metallurgical reasons, such plants have been installed. The operators of installed processes are also confronted with the serious and difficult problem of disposing of the waste products of these operations.

The removal of sulphur dioxide from industrial gases will not eliminate sulphur dioxide from our environment. Much of the ambient sulphur dioxide is produced by domestic heating systems, internal combustion engines, and certain natural processes which are not subject to legislative control. The seasonal sulphur dioxide content of our atmosphere is observed to vary with our domestic heating requirements, not only in the city, but equally so in outlying rural areas. Industrial processes on the other hand are essentially continuous and the sulphur dioxide produced by them is relatively constant. Eliminating this source then, without eliminating others, may only improve our situation marginally. In this context we should note that the sulphur dioxide levels in the Hamilton area, as measured by the Ministry of the Environment, have been in compliance with provincial standards for the past two years. The Ministry has also calculated Stelco's stack emissions and has found these to be close to provincial standards for sulphur dioxide. Fortunately, these findings permit time to develop a completely satisfactory solution to the total sulphur problem.

In conclusion, it is our opinion that the best available technology for desulphurization of industrial gases will not provide an overall benefit to our environment. The partial reduction in atmospheric sulphur dioxide must be weighed against the greater quantity of wastes that would be formed and the increased energy consumption to achieve this purpose. We feel that this is a weak trade-off. On the other hand, we expect that our fuel situation will increasingly demand the use of poorer-quality, higher-sulphur fuels and the need for effective sulphur control will become essential. For this reason, we propose to maintain an active surveillance of new developments in desulphurization technology on a world basis and to supplement this with an active research program of our own.

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